



Arctic Collaborative Environment (ACE)

FY11

Project Update
16 July 2013

- **Participants**
 - **COCOM Sponsor: USEUCOM & NORAD-USNORTHCOM**
 - **Oversight Executive: OASD/RE/RFD; Elmer Roman**
 - **Operational Manager: USEUCOM; Steve Spehn**
 - **Technical Manager: NASA MSFC; Joe Casas**
 - **Transition Manager: VCSI; Marty Kress**
 - **Other participants / partners:**
 - U.S. National Ice Center (USNIC); U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC); University of Alaska Fairbanks (UAF); University of Alabama in Huntsville (UAH); Defence Research and Development Canada (DRDC); Canadian Ice Service (CIS); Environment Canada (EC); Russian Arctic and Antarctic Research Institute (AARI)



Operational Problem Statement

- **No general purpose, Arctic awareness, decision-support system**
- **No overarching operational architecture or universal core system for data & tool integration**
- **No common integrator of varied data sources**
- **Inadequate environmental visualization to support development of cooperative Arctic policies**
- **Inadequate access to models to support planning**
- **Insufficient integration of environmental data to support ongoing and future operations**

The ACE JCTD provides immediate capabilities and jump-starts new solutions to common problems shared across the Arctic Community



Quick Overview

- **ACE provides a web-based, open-access, Arctic-focused, environmental research and decision-support system**
 - Integrates data from existing remote sensing assets and in situ observations
 - Provides monitoring, analysis, and geo-rectified visualization based on earth observation data and modeling
- **ACE enables local, regional, and international cooperation and coordination on long-term environmental planning and near-term actions in response to climatic and environmental changes occurring in the Arctic Region**
- **ACE leverages prior earth science applications work done at NASA Marshall Space Flight Center (MSFC), to include:**
 - Real Time Mission Monitor (RTMM)
 - Short-term Prediction Research and Transition Center (SPoRT)
 - Servir
 - Advanced Microwave Scanning Radiometer–Earth Observing System (AMSR-E)
- **ACE capitalizes on the International Polar Year (IPY)**
 - Enables and promotes the exchange of data and models for use in the Arctic Region
 - Provides a collaborative environment for common areas of interest for the Arctic Nations
- **ACE identifies and defines new data sets, instruments and infrastructure for situational awareness and missions that will provide enhanced societal benefits within the arctic**
- **ACE can be directly applied to other regions and applications**



Support to National Priorities

- **NSPD-66 Arctic Region Policy:**

- "Increase Arctic maritime domain awareness in order to protect maritime commerce, critical infrastructure, and key resources."
- "Accurate prediction of future environmental and climate change on a regional basis, and the delivery of near real-time information to end-users, requires obtaining, analyzing, and disseminating accurate data from the entire Arctic region, including both paleo-climatic data and observational data."
- "Lead the effort to establish an effective Arctic circumpolar observing network with broad partnership from other relevant nations."

- **ACE:**

- **Increases Arctic maritime domain awareness** by integrating multiple datasets— to include satellite data, Automated Information System (AIS), and into a user-defined operational display
- **Delivers near-real-time information** from diverse data sources, to include: weather history, current observations, and forecasts; sea-ice extent history and modelling; archived remote sensing; and ongoing research
- **Establishes the foundation for interactive collaboration** on international Arctic environmental data



Support to National Priorities

- **National Strategy for the Arctic Region:**

- "Enhance Arctic Domain Awareness – ... The United States will endeavor ... to promote maritime-related information sharing with international, public, and private sector partners, to support implementation of activities such as the search-and-rescue agreement signed by Arctic states."
- "Pursue Innovative Arrangements – Foster partnerships with the State of Alaska, Arctic states, other international partners, and the private sector to more efficiently develop, resource, and manage capabilities ..."

- **ACE:**

- **Provides a collaborative environment** for the controlled sharing of open and proprietary maritime-related information, to include: weather and sea-ice extent data from national and international sources; Automated Information System (AIS) data from international AIS providers; and University research data
- **Provides** functional capabilities requested by U.S. Coast Guard District 17 for **support to international Arctic Search and Rescue (SAR)** operations;
- **Works closely with the LtGov of Alaska and the University of Alaska Fairbanks** to address data requirements to support Alaskan transportation infrastructure and other economic sectors
- **Enables joint U.S., Canadian, and Russian research** on sea-ice extent

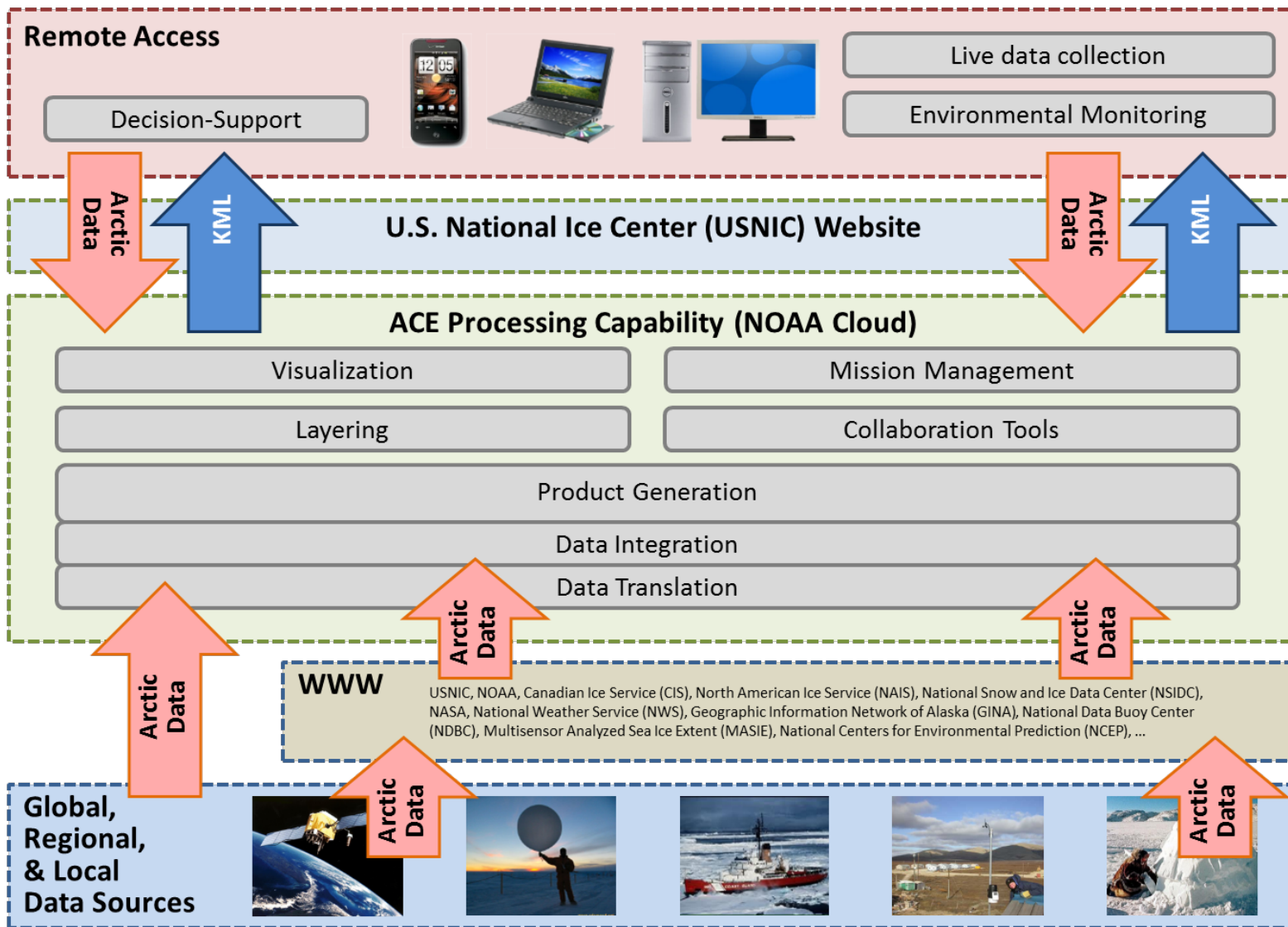


Support to National Priorities

- **Quadrennial Defense Review, February 2010:**
 - "Special attention is required to develop domain awareness tools for the Arctic approaches as well."
 - "The Department will also enhance defense relationships and continue to work with Canada in the context of regional security, increased interaction in the Arctic ..."
- **ACE:**
 - **Provides a general purpose regional awareness tool** with a user-defined operational view
 - **Supports "behind the firewall" operations** for use over Intranets, classified networks, or otherwise restricted networks
 - **Is coordinating** with the Canadian Department of National Defence (DND) for **the transfer of \$100K (\$US) from DND to ACE** to support continued development



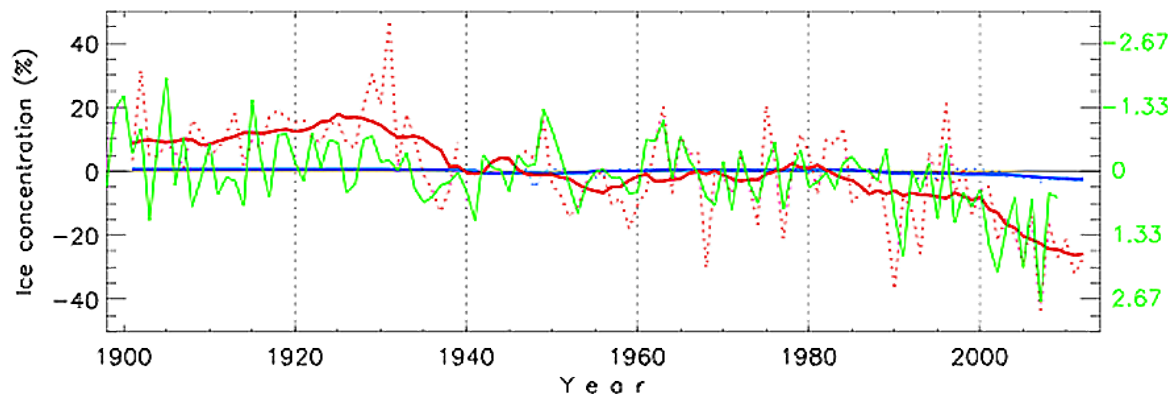
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International Highlights

- **Endorsed as a primary task under the Executive Committee for Sustaining Arctic Observing Networks (SAON)**
 - SAON is co-chartered by the Arctic Council and the International Arctic Science Committee (IASC) “to achieve long-term Arctic-wide observing activities that provide free, open, and timely access to high-quality data that will realize pan-Arctic and global value-added services and provide societal benefits”
- **Formally endorsed by NOAA Administrator at International Polar Year (IPY) Conference in Canada**
- **Secured archived Arctic sea-ice coverage unique data sets from Russia’s Arctic and Antarctic Research Institute (AARI) covering 1933–1990**
- **Enabled joint U.S., Canadian, and Russian research on sea-ice extent (extract below)**



Time series of Siberian shelf sea-ice concentration in April (blue) and August (red) and surface air temperature (SAT, green) anomalies. Unsmoothed SAT anomalies are shown by dotted lines.



Unique Aspects

- **Free to end users and openly accessible by all through the public Internet**
 - Supports most modern browsers
 - Requires only JavaScript and the Google Earth Plugin
- **Open source for community development and special purpose replication**
 - Designed for immediate extension to other regions of the world
- **Provides general capabilities that end users can customize for various purposes**
 - Users can Share their own data files and share this information to a specific group of people (researchers, rescuers, educators, etc.) or share with the general public
 - Users can share uniquely tailored workspaces (maps and data views) within their own group
 - Group collaboration and support for areas/topics of interest
- **Rich catalog of data sources, including searchable metadata**
 - Access to multiple data sources, including complex forecast data such as NetCDF
 - (Easily) extensible to include additional data sets – e.g. just integrated database of Russian Arctic surface air temps and plan to integrate NIMBUS satellite images, sea ice forecast model, HDF, GRIB2 & ShapeFiles
- **Multiple simultaneous 2D Map and 3D Globe map views with persistence, including differing layers, geographic regions, and zoom levels**
 - Working with University of Alaska Fairbanks to implement additional projections
- **Sustained through future collaborative research proposals and workshops**
 - ACE Academic Support Group will support collaborative proposal development for research funds
- **Exposes an application programming interface (API)**
 - Enables external access via web applications
 - NOAA's Arctic Environmental Response Management Application (ERMA) plans to use the API

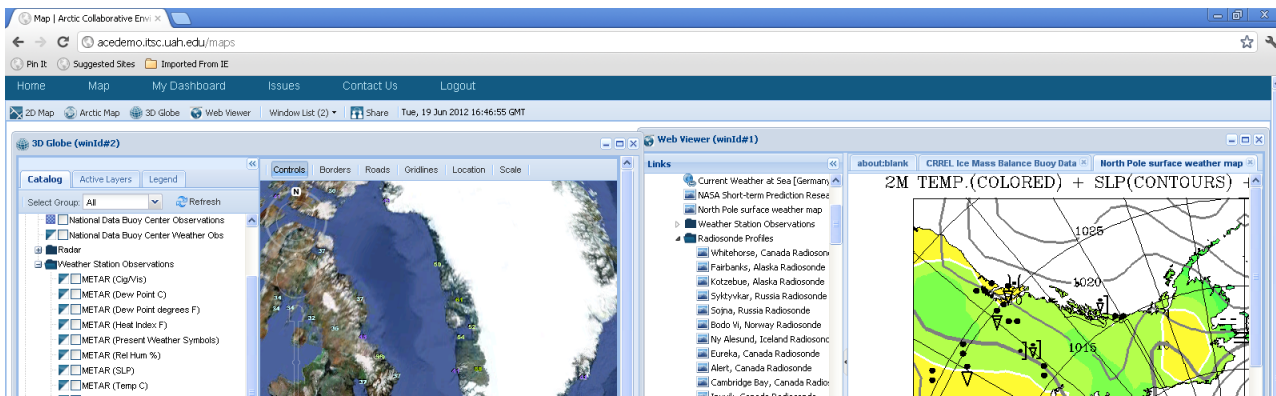


Other Key Dimensions

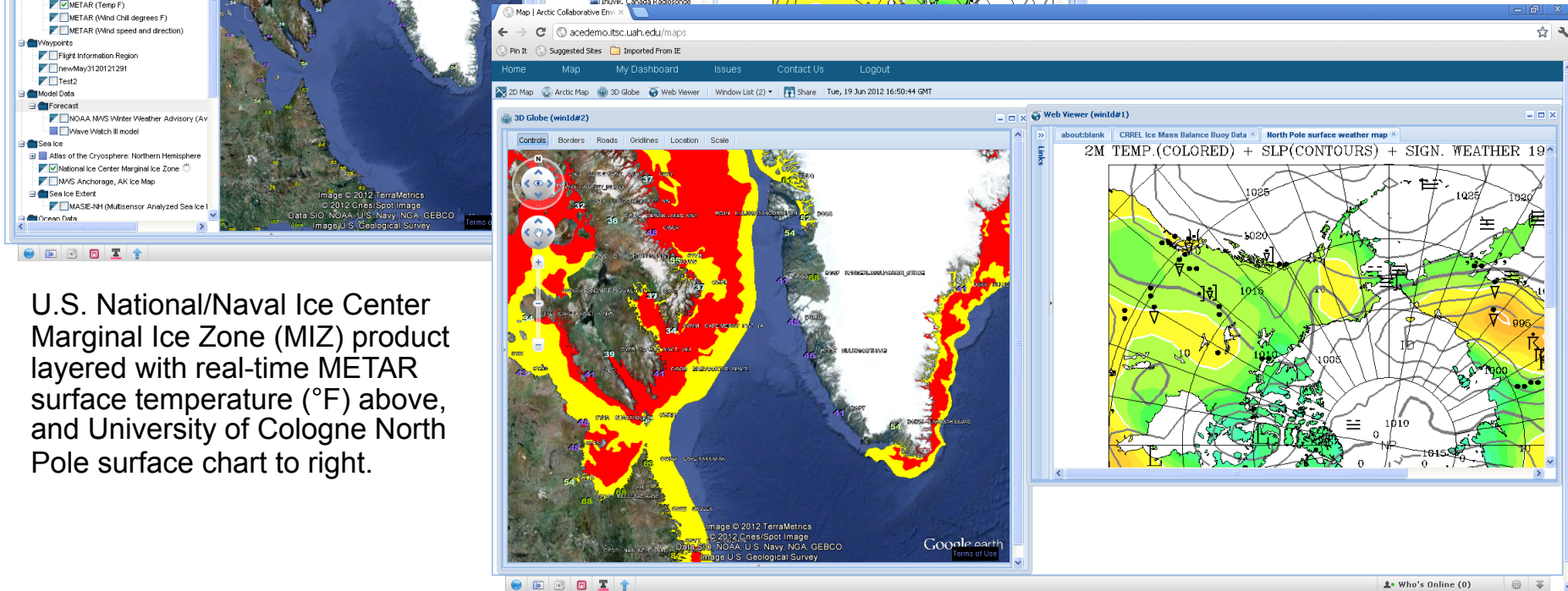
- **Team works closely with key domestic and international Arctic organizations**
- **Project has been endorsed by NOAA Arctic Emergency Response Management Application (ERMA) as complementary**
- **Russian Arctic and Antarctic Research Institute (AARI) has shared sea-ice extent data**
- **Strongly supported by the Canadian Embassy**
- **Team works closely with leading Arctic research universities**
- **Identified by Navy Arctic Capabilities Gap Assessment as a key capability**
- **University of Alaska Fairbanks plans to capitalize on ACE by enabling future research activities**
- **Defence Research and Development Canada (DRDC) has committed to funding ~\$100K**
- **ExactEarth and OrbComm have agreed to provide Automated Identification System (AIS) data at no cost to ACE for one year**
- **ACE has informed resourcing options for ARC-Sat, a multi-role communications satellite system for polar regions**



Screenshot (1 of 3)



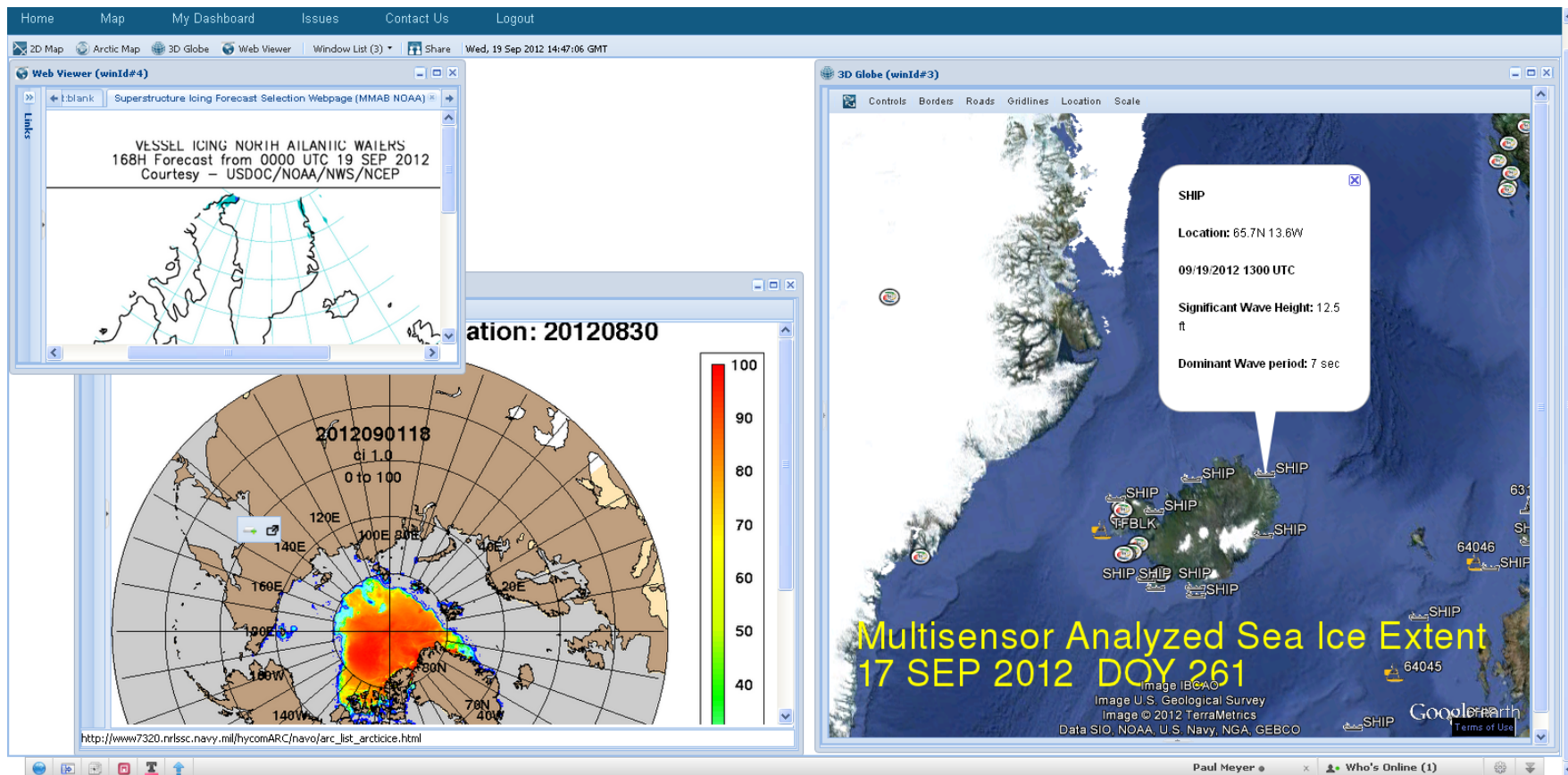
Users select from data catalog, which includes KML/KMZ, WMS, webpages and images. Users can collapse and reopen the data catalog to better view data sets and layer new data sets.



U.S. National/Naval Ice Center Marginal Ice Zone (MIZ) product layered with real-time METAR surface temperature (°F) above, and University of Cologne North Pole surface chart to right.



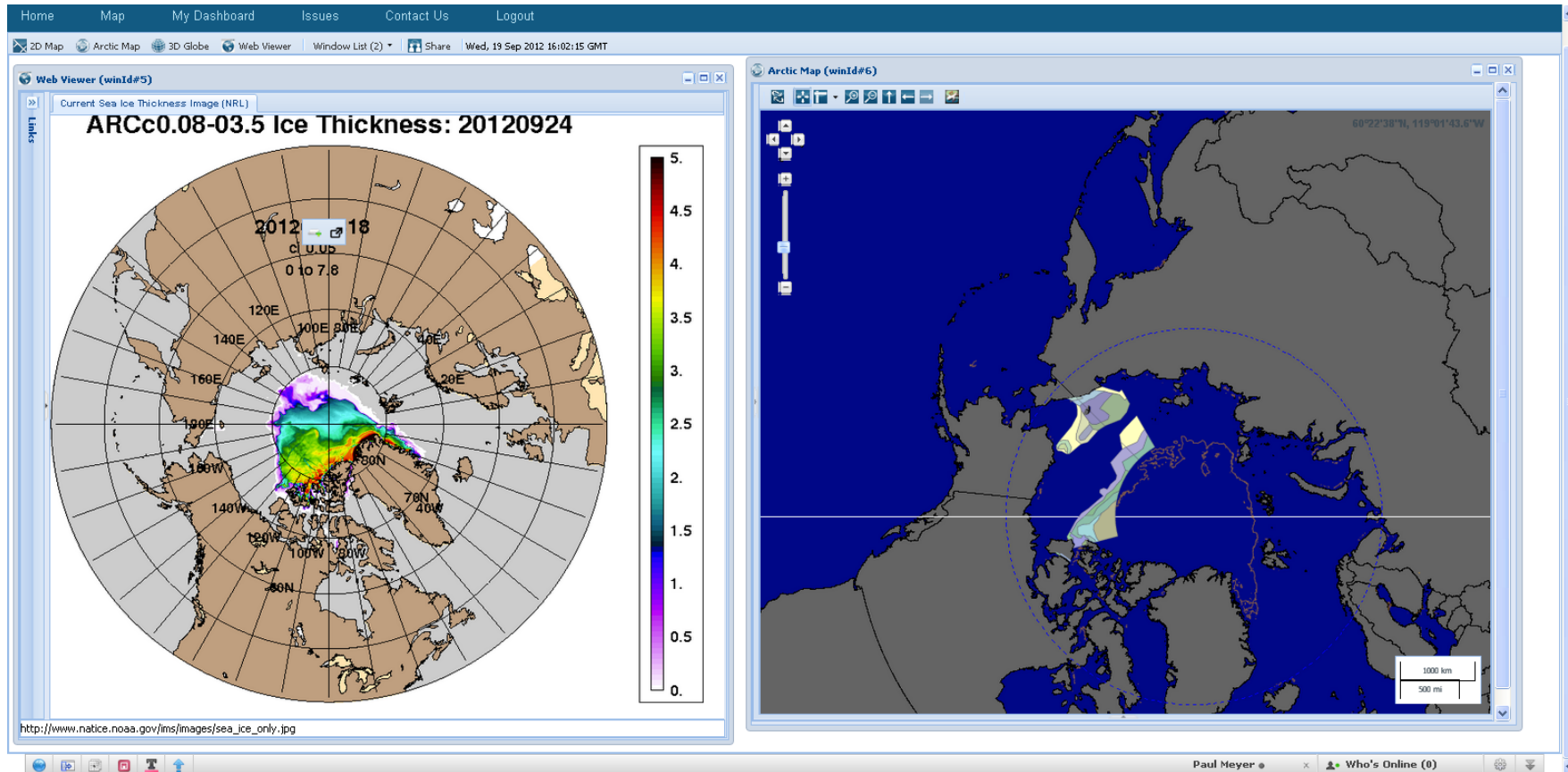
Screenshot (2 of 3)



NOAA superstructure icing forecast for northern Atlantic (upper left) next to Arctic Cap Nowcast/Forecast System (ACNFS) ice concentration (bottom left) next to U.S. National/Naval Ice Center (NIC) and the National Snow and Ice Data Center's (NSIDC) daily Multisensor Analyzed Sea Ice Extent (MASIE) product layered with near real-time ship and buoy information from National Data Buoy Center (right).



Screenshot (3 of 3)



Arctic Cap Nowcast/Forecast System (ACNFS) ice thickness on left, next to National Weather Service Anchorage, Alaska Sea Ice Desk daily sea ice thickness product layered with PolarView's sea ice extent (as defined by 15% concentration) on right.



Partnerships

- **ACE JCTD Development Team**

- Office of the Deputy Assistant Secretary of Defense for Rapid Fielding (ODASD(RF))
- U.S. European Command (USEUCOM)
- North American Aerospace Defense Command (NORAD) / U.S. Northern Command (USNORTHCOM)
- National Aeronautics and Space Administration (NASA) Marshall Space Flight Center (MSFC)
- Von Braun Center for Science & Innovation (VCSI)
- University of Alabama in Huntsville (UAHuntsville)
- U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC)
- Johns Hopkins University Applied Physics Lab (JHU-APL)
- University of Alaska Fairbanks (UAF)

- **Arctic Operations**

- U.S. National Ice Center (USNIC)
- National Oceanic and Atmospheric Administration (NOAA)
- U.S. Coast Guard District 17
- U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)
- Canadian Embassy in DC
- Sustaining Arctic Observing Networks (SAON)

- **Arctic Research**

- NASA Goddard Space Flight Center (GSFC) NASA GSFC
- Russian Arctic and Antarctic Research Institute (AARI)
- University of Alaska Fairbanks (UAF)
- University of Maryland College Park (UMCP)
- Aurora Research Institute (ARI)
- University of Delaware (UD)



Status

- **February 2013**

- Identified in the National Science and Technology Council's Arctic Research Plan: FY2013–2017, as one of the *"key assets of cyberinfrastructure that are important for research and education in the Arctic"*

- **March 2013**

- Successfully executed Technical and Operational Demonstrations

- **July 2013**

- Establishing operational capability at University of Alaska Fairbanks

- **FY14**

- Will transition to a cloud architecture

Overview of ARC-Sat

Utilization of Emerging Technology and Small Sats to
Address Critical Needs of Research & Operational
Communities in the Polar Regions

16 July 2013



ARC-Sat Operational View

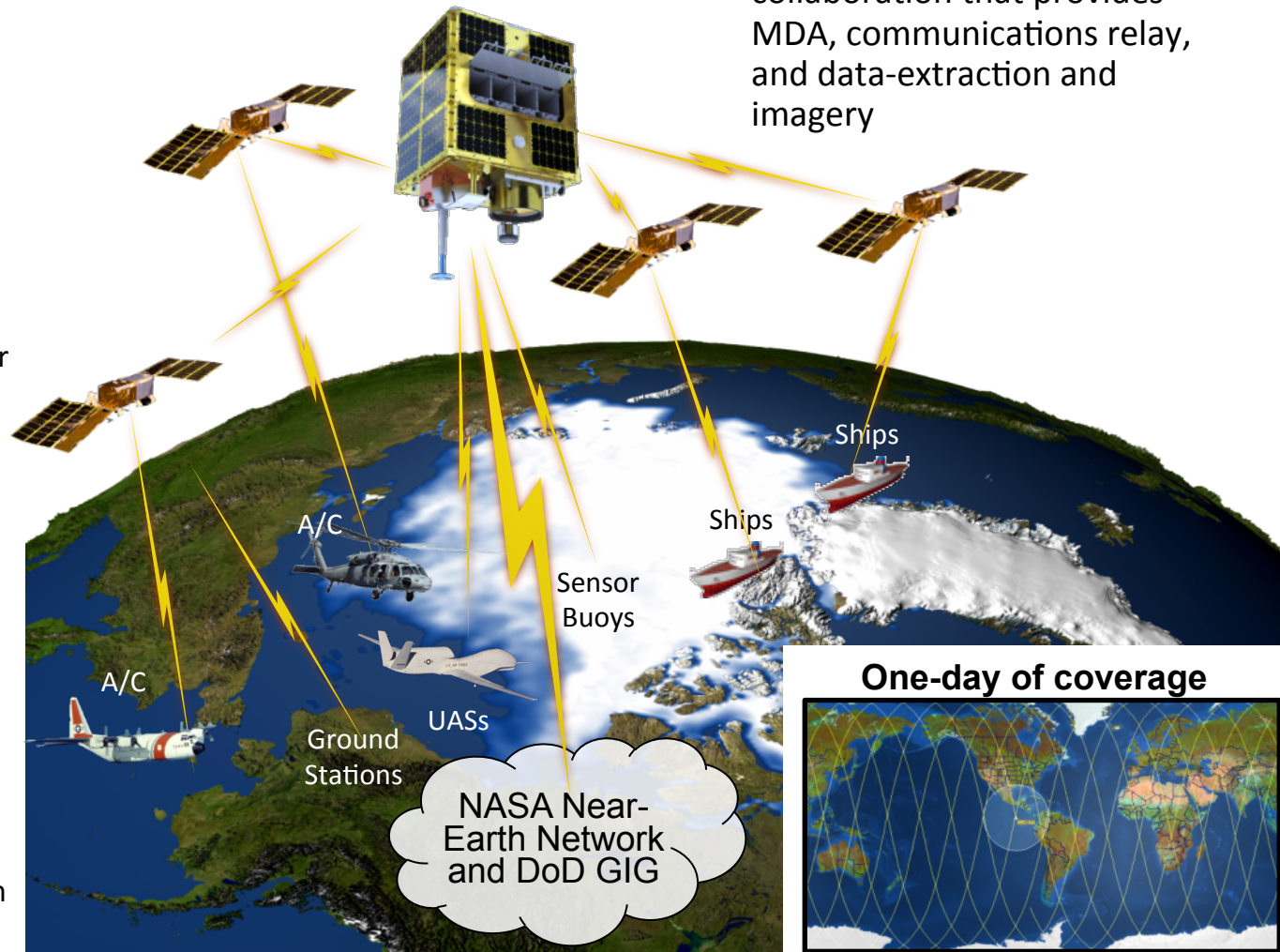
Mission Concept

- 1 Minisatellite Mothership (ESPA Class)
 - CubeSat Launcher
 - AIS, Data-X, & EPIRB Receivers
 - Communications package
- 4 Communications CubeSats
- 650 km low-earth-orbit (LEO)
- Circular orbit (eccentricity = 0)
- 90-98° Inclination
- Up to 150 Mbps total data throughput
- UHF, S, C and X-band bent pipe or network distribution
- EPIRB relay supports Search & Rescue

Payloads

- Mothership has extensive computational, control, and data store-and-forward capacity
- Mothership and 4 CubeSats each with 2 software-defined radios
- Mothership candidate payloads
 - AIS provides global Maritime Domain Awareness (MDA)
 - Data-X provides data collection from unattended sensors
 - Imagery

An innovative, multi-agency collaboration that provides MDA, communications relay, and data-extraction and imagery



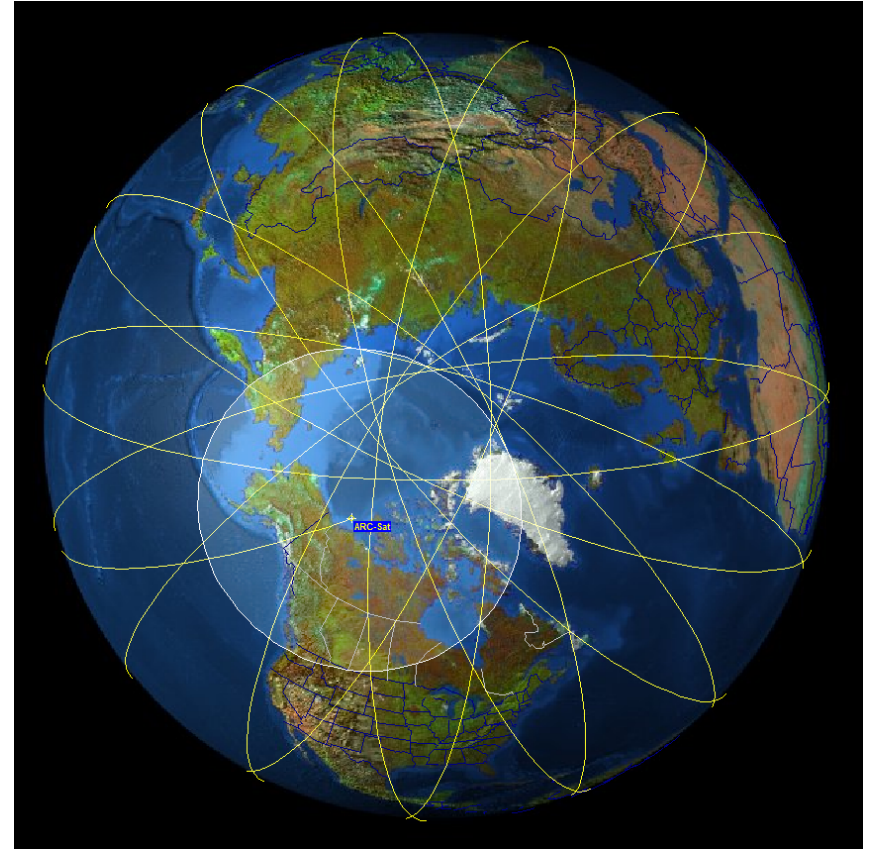
ARC-Sat Provides Year-Round Global Capability, with an Arctic Focus

Orbit

- Altitude: 650 km
- Eccentricity: 0 (Circular)
- Inclination: 98°
- Period: 97.7 minutes

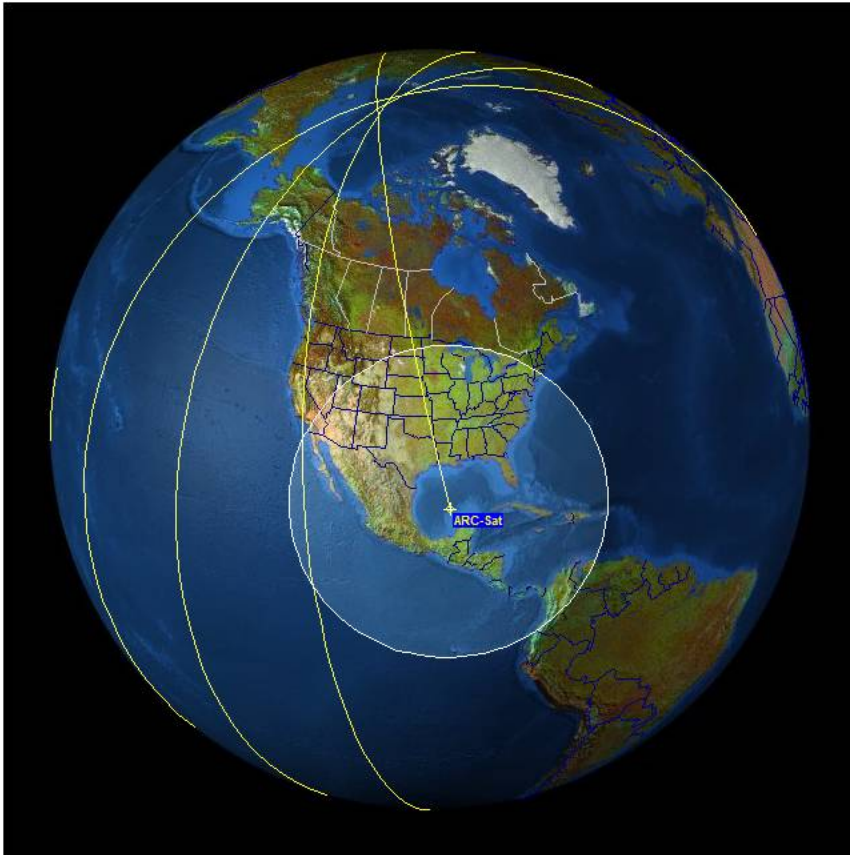
Ground Track

- Diameter: 5,529 km
- Area: 24 million km²
- Speed Over Ground: 6.836 km/s
- Time in view for overhead pass: 13.48 min
- With a track overlap of 50.8% at the Equator, ARC-Sat will cover the Earth twice per day
- ARC-Sat will provide service to each point on the Earth
 - Minimum of 4 times per day at the Equator
 - Up to 14 times per day at the Poles
 - About 11–12 times per day over Alaska

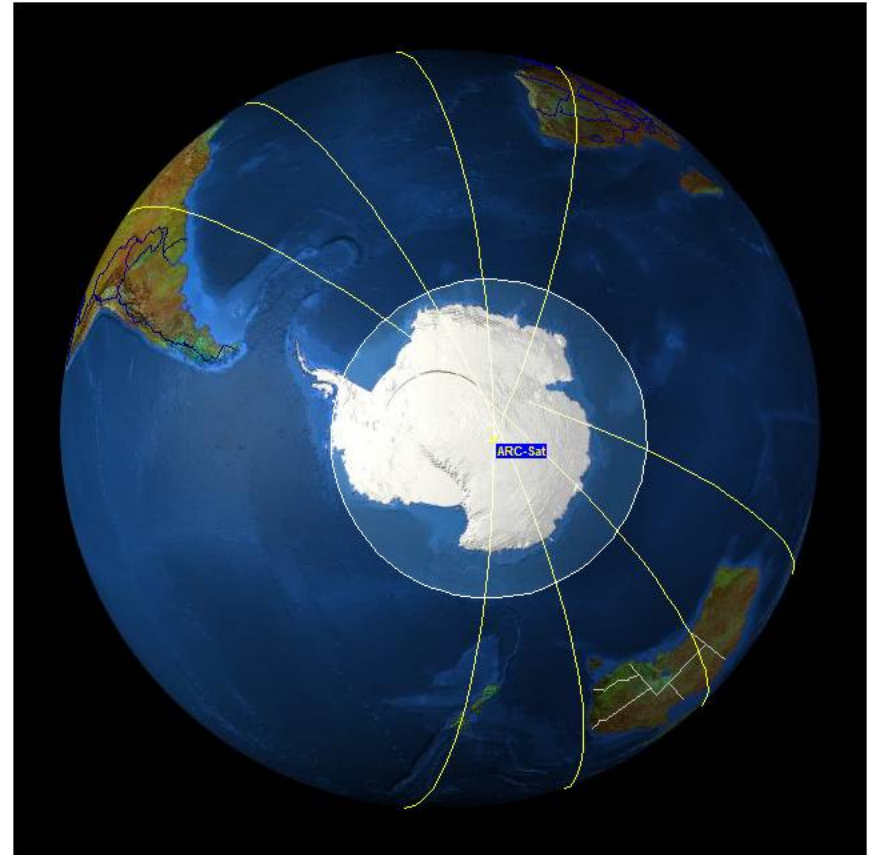


Typical ground coverage and track for 24-hour period

Coverage in Other Critical Regions



North America



Antarctic

FAST-Sat “Mothership” Mission



Capability	Mothership	Each NanoSat
Mass (kg)	180	< 14
Size (cm)	61 x 71 x 97 (ESPA class)	10 x 10 x 30
Stabilization	3-axis	3-axis
Attitude Control	0.1° with 45-minute recovery	0.1°
Attitude Knowledge (°)	0.02	0.05
Navigation and Control		Reaction wheel with atomic clock and high-precision GPS utilizing DARPA F6 algorithms
Propulsion	None	Low-toxicity green monopropellant; ion; or electric
Orbit	400–850 km; 30–99°; 1–3 years	1–3 years (mission dependent)
Communications	AIS, Data-X, & EPIRB receivers, and UHF, S, C, and X-band communications; store-and-forward	Electronically steerable patch array antennas matched with up to 3 SDR systems for UHF,S,C,X and Ka bands that can support satellite interlink, command and control, and serve as communications payloads
Downlink (Mbps)	5 (S-band), 150 (X-band)	UHF, S, C, X, and Ka Bands
Uplink (Kbps)	300	
Crosslink (Mbps)	3	
Payloads	4 3U or 2 6U CubeSats, with on-demand, on-orbit deployment	Observations, communications, AIR, SAR, etc.
Payload Mass (kg)	35–45 Total	< 7
Payload Power (W)	25–35 Average	Up to 100 average orbit
Payload Data (GB)	96	10
Launch Options	ESPA compatible: Athena, Minotaur I, Minotaur IV, Falcon 9, Delta IV, Atlas V, Super Strypi (TBD)	Primary payload on: Super Strypi (TBD), SWORDS, and ALASA; primary or secondary payload on Athena or Minotaur
Heritage	FASTSat-HSV that was flown as part of an STP activity from Kodiak as a secondary payload on a Minotaur	NASA NanoSail, NGI Plymouth and Mayflower, and new Novaworks satellite systems that are part of the DoD ZombieSat, DARPA SeeMe, and DARPA SatLet projects